

Modeling of Irrigation Management to Mitigate Pesticide Leaching in Vulnerable Soil

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Overview of DPR's LEACHM Modeling Tool

- Initially developed to identify mitigation measures for California ground water contaminants (pesticides listed in CCR section 6800a)
 - Irrigation management identified as effective mitigation in leaching soils
 - Required irrigation efficiencies to increase from 60 – 70% (surface irrigation) to 80% (pressurized irrigation)
 - Development & verification of modeling tool based on pesticides found in California ground water from non-point-source detections in leaching soils:

atrazine bromacil diuron simazine norflurazon hexazinone
- Model later adapted to evaluate leaching potential of new pesticides submitted for California registration

Development of LEACHM Modeling Tool

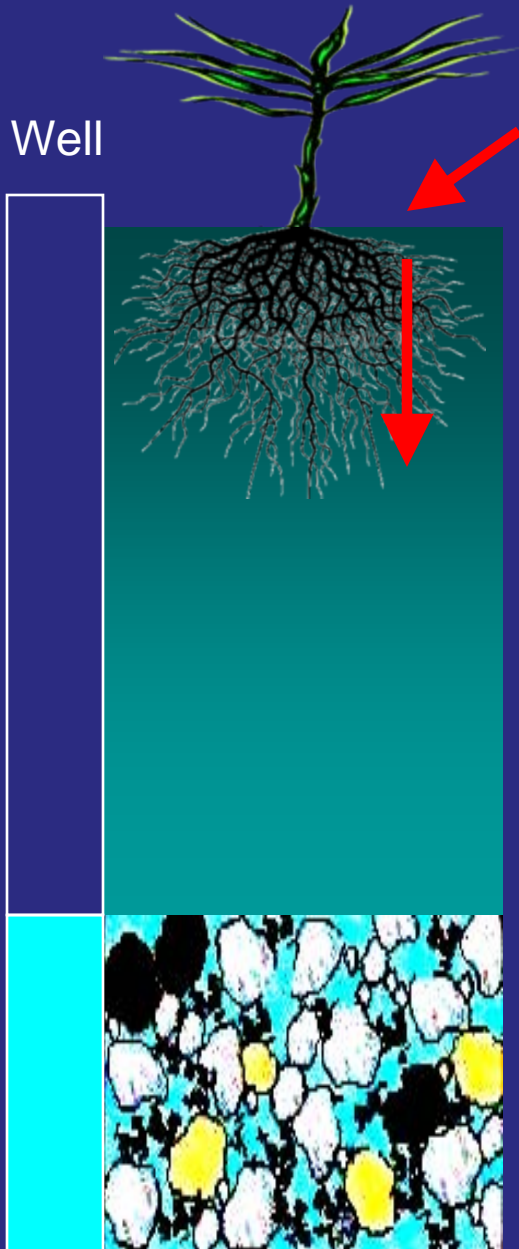
- Development of modeling process relied on physical/chemical properties and non-point-source detections in ground water of: atrazine bromacil diuron simazine norflurazon hexazinone
 - All exhibit physical/chemical properties consistent with persistence and mobility in soil

	Soil mobility parameters		Soil persistence parameters			
	Solubility (mg/L)	Koc (cm ³ /g)	Aerobic metabolism (days)	Anaerobic metabolism (days)	Hydrolysis (days)	Field dissipation half-life (days)
	SNV > 3	SNV < 1900	SNV > 610	SNV > 9	SNV > 14	
Bromacil	929	17	347	73	stable	157
Diuron	36	499	372	995	1,290*	118
Atrazine	33	93	146	159	stable	117
Simazine	6	340	110	71	stable	90
Norflurazon	34	617	172	348	2,650*	365
Hexazinone	29,800	642	222	232	stable	118

- All are soil applied herbicides with significant use in California
- All found in California ground water in multiple wells by DPR

	State-wide use 1990 – 2009 (lbs)	Average crop application rate (lbs/acre)	Well water concentration ug/L		Average depth to ground water (feet)	Number of unique well detections
			95 th percentile	50 th percentile		
Bromacil	1,663,961	1.23	3.68	0.44	42	236
Diuron	22,688,605	1.45	1.20	0.25	44	457
Atrazine	964,349	1.37	0.70	0.15	49	176
Simazine	15,121,778	1.24	0.59	0.14	42	624
Norflurazon	3,303,174	1.10	0.57	0.10	34	72
Hexazinone	2,262,660	0.53	0.26	0.08	35	23

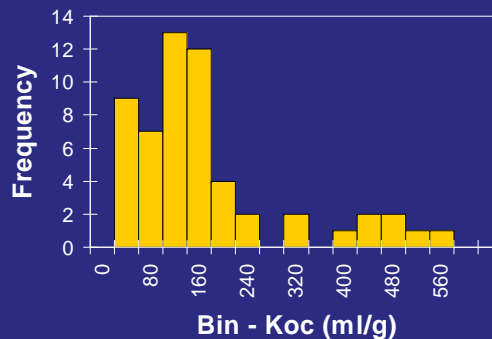
Conceptual Modeling Process



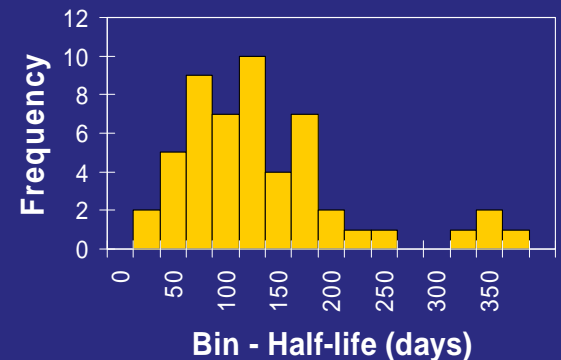
Pesticide input

- Physical/chemical property of atrazine, bromacil, diuron, simazine, norflurazon and hexazinone grouped based on their exceedance of SNV's and non-point-source detections
 - Median and nominal values used for solubility, vapor pressure and pesticide application rate
 - Input distributions formed for Koc and field dissipation half-life:

Koc

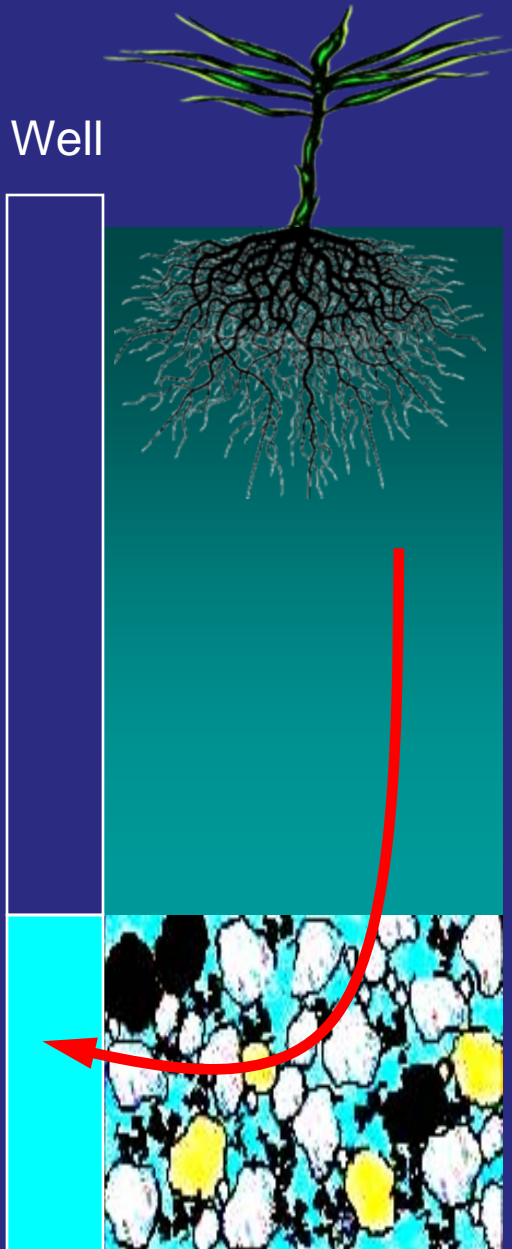


Field dissipation half-life



- LEACHM pesticide fate and transport model initiated for 1000 executions

Conceptual Modeling Process



Simulated leaching of grouped pesticides using empirical model

- Movement of residues modeled with velocity estimate
- Residue dissipation rates not available
 - Studies indicate dissipation rates are slower
 - Default to longest field dissipation rate for grouped pesticides (1 y)
- Residues diluted into annual recharge water (0.5 m depth)
- Age of ground water recharge (1 – 30 years, median 6 y)
- Residues dissipation dominated by hydrolytic processes but rates are not available but typically very long
 - Default to longest field dissipation rate for grouped pesticides (1 y)

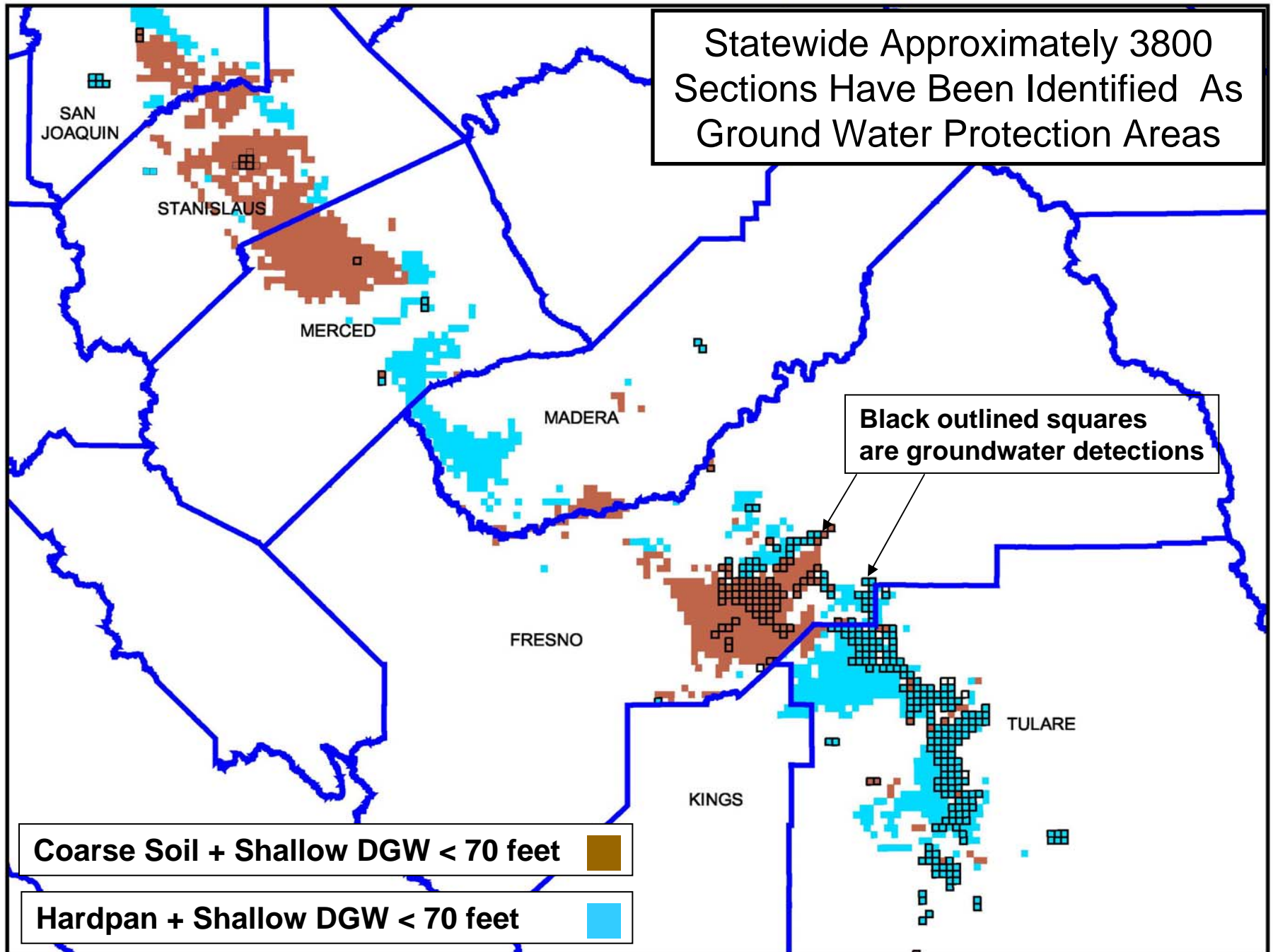
Statewide Approximately 3800
Sections Have Been Identified As
Ground Water Protection Areas

Black outlined squares
are groundwater detections

Coarse Soil + Shallow DGW < 70 feet

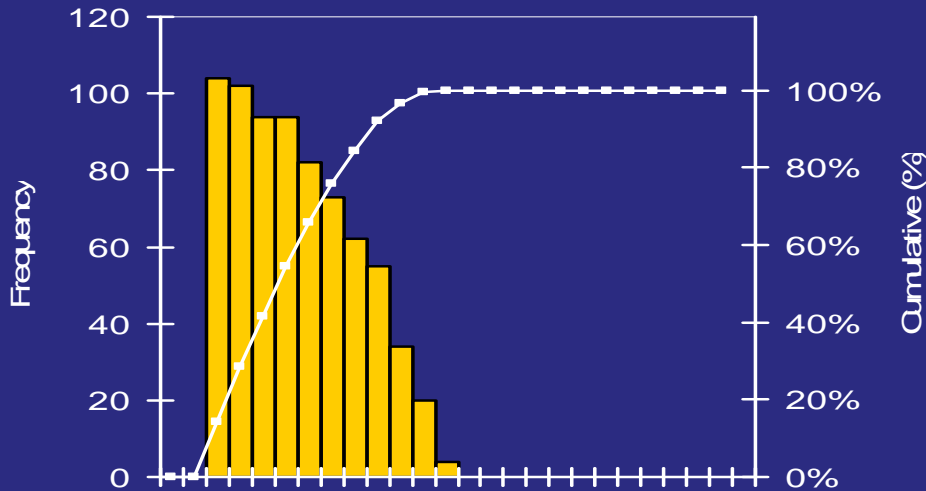


Hardpan + Shallow DGW < 70 feet



Verification of Probabilistic Model

atrazine bromacil diuron simazine norflurazon hexazinone



Model predictions for combined pesticides

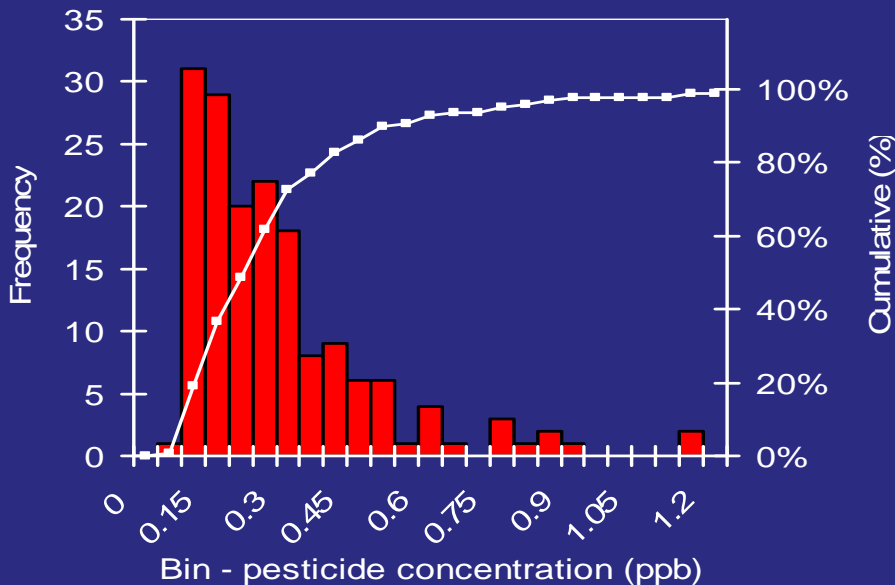
- Water application at 160% plant demand ~
65% irrigation efficiency

25th percentile = 0.14 ppb

50th percentile = 0.23 ppb

75th percentile = 0.35 ppb

95th percentile = 0.48 ppb



Observed data for combined pesticides

25th percentile = 0.12 ppb

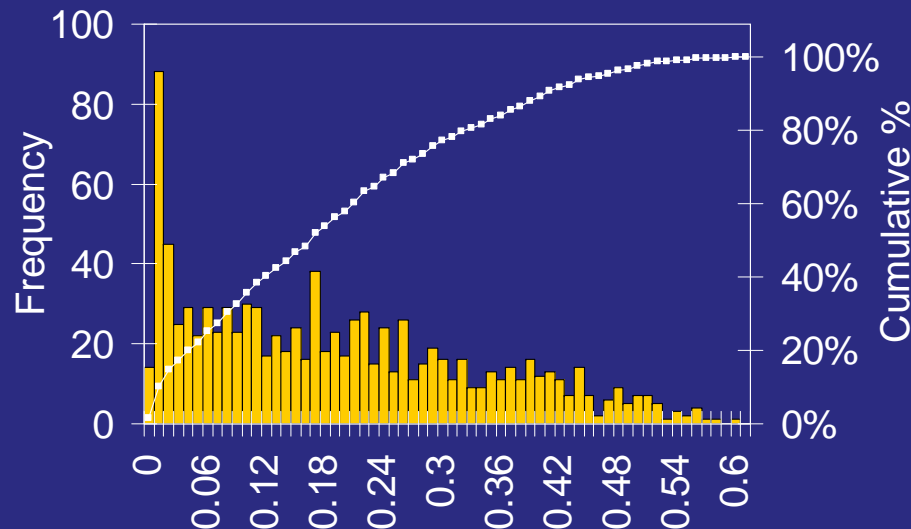
50th percentile = 0.21 ppb

75th percentile = 0.32 ppb

95th percentile = 0.74 ppb

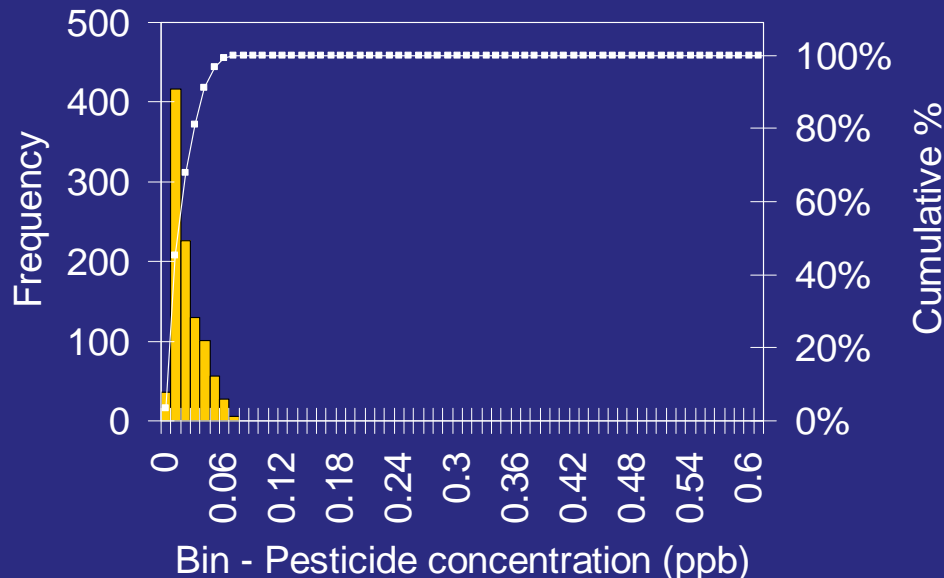
Mitigating Pesticide Movement to Ground Water

atrazine bromacil diuron simazine norflurazon hexazinone



Model predicted well water concentrations for combined pesticides

- Irrigation at 160% plant demand ~ 65% irrigation efficiency
- Concentration 95th percentile = 0.47 ppb



- Irrigation at 133% plant demand ~ 80% irrigation efficiency
- Concentration 95th percentile = 0.05 ppb